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WORKER–PROTECTIVE CONTROLS

Engineering Controls To Reduce Airborne, Droplet and Contact Exposures During Epidemic/Pandemic Response

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Expedient Patient Isolation Rooms

Oftentimes, local and national protective guidance issued during a pandemic might call upon the use of airborne infection isolation rooms (AIIRs) for patients and/or specific patient procedures. Within U.S. hospitals, AIIRs are patient rooms with specific engineered features, intended to isolate and more-quickly remove potentially infectious patient aerosols. During an epidemic or pandemic, the demand for AIIRs may exceed their availability. When this occurs, healthcare facilities may choose to use portable fan systems with high-efficiency particulate air (HEPA) filtration to establish surge AIIR capacity. Although there is substantial research indicating potential shortcomings when HEPA fan/filter units are deployed incorrectly, there has historically been minimal guidance on how to deploy these units correctly. The National Institute for Occupational Safety and Health (NIOSH) has developed guidance for using portable HEPA filtration systems to create expedient patient isolation rooms. The Expedient Patient Isolation Room guidance is researched based and is an effective solution for surge isolation capacity during outbreaks when traditional airborne isolation rooms are unavailable.

In ventilation system design, a "zone" is a space served by a ventilation system. The expedient patient isolation room approach creates a high-ventilation-rate inner isolation zone that sits within a larger ventilated zone. Contaminated air is contained within the inner zone where it is quickly captured and cleaned while the outer zone remains free of contaminant and is a safer environment for healthcare facility staff, other patients and visitors. The inner zone is the space immediately surrounding an infectious patient's bed. The HEPA filtration system is placed between the inner and outer zones. Contaminated air is pulled from the inner zone into the HEPA filtration system, where it is cleaned and then discharged into the outer zone, thus maintaining a negative pressure relationship of the inner zone relative to the outer zone. Using a HEPA filtration system with a high air-cleaning capacity to provide at least 12 air changes per hour (ACH) to the overall patient room, this approach results in an air-cleaning that's equivalent to a traditional AIIR, while providing an even higher air-cleaning rate within the inner isolation zone. The inner isolation zone boundary is created using a floor-to-ceiling retractable curtain that replaces the traditional patient curtain surrounding the patient bed.

Make-up air into the inner zone flows through a designated curtain gap that also serves as the entrance point into the inner zone. The outer zone is the space between the inner zone and the patient room walls. Depending upon the size of the room, one or two inner zones may be located within the same patient room and share the same outer zone. Air is removed from the inner zone(s) through the use of a freestanding HEPA filtration system that utilizes a nondirected air inlet. The HEPA system can be positioned to serve up to two patient inner-zones simultaneously, with no exchange of contaminated air between the two inner zones. See Figure 1 for an example expedient patient isolation room for 2-bed patient room.

Placement of the HEPA filtration system will be influenced by the room configuration. Though not always feasible, the optimum goal is to not only contain the contaminant within the inner zone but to generate directed airflows within the inner isolation zone that capture and pull the contaminant directly into the HEPA filtration unit. When successfully achieved, the directed airflows allow for prompt removal of contaminated air within the worker-occupied areas of the inner zone. Combining this protective effect with the higher ventilation/filtration rate of the inner isolation zone (in comparison with the total room) yields a more rapid removal of airborne contaminant. Regardless of whether these directed airflows are successfully achieved, the inner isolation zone's negative pressure containment aspects will dramatically inhibit contaminant migration throughout the patient room, thus reducing the opportunity for airborne and surface contact exposures. The outer zone then becomes a safe haven for donning and doffing of PPE and potentially reduces the need for worker respiratory protection in the outer zone area.

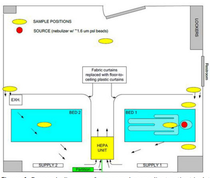


Figure 1. Research diagram of an example expedient patient isolation room for 2-bed patient room.

Results from NIOSH research revealed that the evaluated expedient patient isolation room configurations were universally successful in their ability to contain surrogate infectious aerosol within the inner isolation zones. Performance evaluation sampling showed geometric mean reduction ratios (GMRRs) of 98–99 percent or greater outside the inner zone. While airborne concentration reductions were more variable within the inner isolation zone, depending upon the configuration's ability to establish directed air currents, all of the tested inner isolation zones benefited from the faster air cleaning rate (30–60 ACH) that resulted when the HEPA filtration system was adjusted to provide at least 12 ACH to the overall patient room.

Instructions for Establishing Expedient Patient Isolation Room for Surge Airborne Isolation Capacity Within a Traditional Healthcare Environment

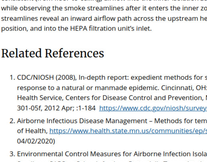
Background

Although they could be modified to conform to an alternate care site, the following instructions describe the creation of expedient airborne infection isolation within a traditional healthcare patient room. **The expedient isolation techniques described are intended to be an emergency alternative to establish surge capacity in airborne infection isolation. It is intended for use during an infectious disease emergency when insufficient engineered airborne infection isolation rooms are available to meet patient demand.** Selection of patient areas suitable for conversion into expedient patient isolation room configurations should be made in consultation with the healthcare facility's safety officer, infection control, and building facilities department participation. Selected patient isolation zones should be evaluated to ensure fire sprinkler coverage is not significantly impaired by the isolation curtains. The inner patient isolation zones should not include recirculating HVAC wall units or HVAC return air grills unless they can be sealed shut or otherwise isolated from the inner isolation zone. Depending upon the patient room, the zone-within-zone configuration may be set up to serve one or two patients. The following instructions are for the two-patient scenario. The single-patient scenario may be established following the same directions, but with the HEPA filtration system's inlet rotated ninety degrees such that it serves just the one inner isolation zone.

Instructions

Each inner isolation zone requires a physical containment perimeter that encircles each patient bed and its surrounding work area and incorporates a designated opening for air make-up and personnel entry. Inner isolation zone boundaries are based upon the existing patient areas, as defined by their cloth privacy curtains, as well as compatibility with HEPA filter placement within the overall room geometry. For some facility configurations this will result in inner zone boundaries where the make-up air entrance (curtain gap) and exhaust points are located at diagonally opposite corners of the inner zone (See Figure 1). At other locations, the airflow may enter near one corner of the inner isolation zone and flow directly across the head of the bed to an exhaust point at the adjacent corner (Figure 2). During NIOSH testing, while both entrance – exhaust orientations provided excellent contaminant containment within the inner isolation zone, the "across pillow" orientation that resulted in directed air flow across the head of the patient bed provided a more rapid contaminant concentration control within the inner isolation zone itself.

To construct the inner zone boundary, replace the existing cloth curtain with a floor-to-ceiling plastic curtain that will utilize the same curtain track. The plastic curtains can be constructed with medium weight (3.5 to 4-mil) plastic sheeting such as you might find in local hardware stores. Your facility safety officer or jurisdictional code officials may require you to use flame retardant plastic. The top of the plastic curtain should be double-folded (allow extra curtain length to accommodate the double fold) and taped onto itself along the curtain's width using fiber-reinforced tape to create a sturdy tape-reinforced upper-curtain border. Punch holes (or install grommets) along the length of the taped border (use the removed cloth curtain for a guide on hole-spacing) to allow hanging of the curtain using the existing curtain hooks and track, thus retaining the curtain's ability to be opened and closed for movement of bed and equipment. The curtain should extend down to the floor, leaving an approximate ½-inch gap at the top due to the curtain hooks. This gap should be subsequently covered by a loose hanging 12-in long baffle that is constructed of plastic sheeting and secured to the outer edge of the curtain track (but not secured to the curtain itself), thus inhibiting airflow through the gap while not interfering with curtain operation. Incorporation of the 12" baffle results in greater dependence on the curtain entrance gap itself as the predominant source of makeup air into the inner isolation zone.


Two Patient Room: Side-to-side airflow across head of bed
WAIT
(bed 2 in cdrc)
Entry
Cabinet
HEPA
UNIT
Exterior window
Ceiling
Floor
Drywall
Curtain
Curtain
Curtain